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# Offshoring, Factor Price and Welfare: From A Specific Factor View

Yao Liu <sup>\*†</sup>

School of Economics, Nankai University, China  
GEP and School of Economics, University of Nottingham, UK

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## Abstract

This paper presents a specific factor model of a small open economy to show the factor price effect and welfare effect of offshoring. Different to ambiguous factor price effect of offshoring under Heckscher-Ohlin framework, the conclusions of this paper is clear-cut. Offshoring will benefit specific factor (skilled labour and land), hurts some non-specific factor (unskilled labour), and enlarge the skilled and unskilled wage gap in home country. This conclusion is independent of factor intensity of offshoring fragment, complete or incomplete specialization at equilibrium and whether international capital mobility is allowed. However, a welfare loss of home country after offshoring might be possible either with or without international capital mobility because of the redistribution of incomes to different factor owners. If certain amount of unskilled labour is trained to update skills, changes of factor prices are depending on the pre-training equilibrium, international capital mobility and capital intensity of fragments.

**Keywords:** Offshoring, Specific Factor Model, Factor Price, Welfare

**JEL Classification:** F11 F16

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\*Address: B52, Sir Cliver Granger Building, University of Nottingham, Nottingham, NG9 ARD, UK.  
Email: nkly@mail.nankai.edu.cn.

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# 1 Introduction

Since the 1970s, the phenomenon of a rising trend of wage gap between skilled and unskilled labour has become common both in developed and developing countries. This issue attracts a series of theoretical and empirical studies on the mechanism behind. Recently, a wave of studies focused on international trade in intermediates helps to explain the major reason of the wage inequality, besides technological progress and international trade in final goods.

Arndt [1997] develops a 2\*2\*2 model under conventional Heckscher-Ohlin trade model, and shows that offshoring may increase, rather than decrease, employment by creating more jobs in the remaining activities. Offshoring by labour-intensive importable industries will raise both employment and wages, which is good news to the workers. Feenstra and Hanson [1996, 1999] tell a story about fragmentation between USA and Mexico, in which labour is treated differently as skilled labour and unskilled labour. Wage inequality will be enlarged in both countries if USA outsources the least unskilled intensive component, but from the Mexico's point of view, it is the most skilled intensive. They argue that rising wage inequality in Mexico is linked to capital inflows from abroad, which corresponds to an increase in offshoring by multinationals and shifting production in Mexico towards relatively skill-intensive goods, therefore increases the relative demand for skilled labour. Jones and Kierzkowski [2000] continue the analysis by expanding Arndt [1997] to a model of multi-goods 2-inputs. In their model, if a country loses the labour-intensive segment, the wage rate need not fall, dependent on whether the country's factor endowment proportion is greater than either segment, or less than either segment, or lies within the core of diversification of the fragmented process. However, most of the works of offshoring based on the Heckscher-Ohlin framework get ambiguousness of conclusions in terms of wage effects of offshoring or depend on factor intensity of offshoring fragment, which makes relevant policy even harder in practice.

This paper is trying to explain the impact of offshoring from an alternative view: the specific factor model, and trying to show whether the factor price effect and welfare effect of offshoring in specific factor model is robust. I present a general equilibrium model of two countries with perfect competitive industry X and Y. The final goods X is produced by land and unskilled labour, and the final good Y is assembled by the fragment N and M. Only fragment N can be offshored to a lower cost production location. Land and skilled labour are specific factors to each industry, while unskilled labour and capital are mobile. The factor price effect and welfare effect of offshoring can be shown by comparative statics analysis, comparing the post-offshoring factor prices and welfare with the pre-offshoring equilibrium. Not surprisingly, relative wage gap between skilled and unskilled labour will increase after offshoring, independent of factor intensity of offshoring fragments, international physical capital mobility, and specialization degree at the equilibrium. The conclusion of factor price effect of offshoring is more robust than that in H-O framework, and more normal sounding to explain the real world. But the welfare after offshoring might be worsened because of the redistribution of incomes to different factor owners.

Jones [1971] began the specific factor model, and the conclusions have been proved robust. Among very few works on offshoring based on the specific factor framework, Kohler [2001, 2004] presents an international fragmentation model with 2 final-goods 2 intermediate-goods 3 factors. However, my model is the first one to explain offshoring with factor specificity in a standard mathematic way, as far as I know. Another feature of my model is that the labour are treated as skilled and unskilled labour according to its skill and specificity. International capital mobility is highlighted here to show whether the factor mobility is crucial to the impact of offshoring on factor price and welfare.

Analyzing offshoring under specific factor framework is both of theoretical importance and practical significance. In the real world, economy's response to exogenous disturbance may not

cause an adjustment of factor reallocation, if factors are specific to the industry, such as some kind of physical capitals and human capitals. Davis et al. [1998] show that the magnitude of gross job flows falls sharply with the relative level of plant wages. High level of specific human capital with high wages implies greater durability in the employment relationship, which means that higher-wage workers are more specific to an industry comparing to lower-wage workers. Why not take the skilled labour as a specific factor in an industry to investigate the effect of offshoring? Obviously, researchers or designers, after years of education and training, are more professional and stickier to a company, rather than cleaner or housekeeper.

The rest of my paper is organized as follows. In Section 2 we first show the equilibrium of an open economy without offshoring, and then talk about the equilibrium after offshoring with and without international capital mobility. We compare the welfare of home country before and after offshoring in Section 3 and extend the model to consider the unskilled labour training for skilled labour in Section 4. Section 5 concludes.

## 2 Basic Model

We first focus on the equilibrium of small open economy without offshoring, and then compare the equilibrium after offshoring with and without international capital mobility to it. We keep the assumption of specific factor model and try to identify the factor price effect and welfare effect.

### 2.1 Equilibrium before offshoring

As the standard specific factor model, there are two final goods, agricultural product X and industrial product Y, in a perfect competitive open market in country H, facing given world prices. X is produced by land (T) and unskilled labour (L), but Y is assembled by intermediate N and M without further cost. M has more technology content than N, as we need unskilled labour (L) and capital (K) to produce N, and capital (K) and skilled labour (S) to produce M. Land is a specific factor to industry X, and skilled labour is a specific factor to sector M in industry Y. The nonspecific unskilled labour moves between industry X and Y, and capital moves between sector N and M within industry Y. Figure 1 shows the relationship of inputs and outputs in country H.

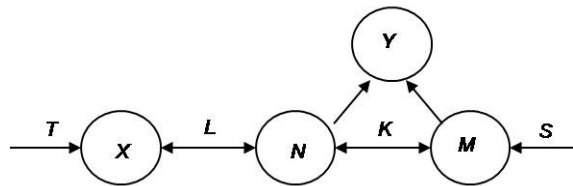


Figure 1: Inputs and Outputs in Country H

Here we assume that offshoring is not applicable at the moment because of production technology or a country's trade policy. All the intermediates (M and N) are produced in country H.  $\bar{T}, \bar{L}, \bar{K}, \bar{S}$  stand for the factor endowments in country H, and  $r_i$  stands for the price of factor  $i$ . The production functions for product X, Y, N, M in country H are Cobb-Douglas function, as shown below<sup>1</sup>:

<sup>1</sup>Superscript of variables in this paper means sector X, N, M or Y.

$$Q^X = f^X(T, L), Q^Y = f^Y(Q^N, Q^M), Q^N = f^N(L, K), Q^M = f^M(K, S), \quad (1)$$

Let the price of X equal to 1, and the price of Y equal to  $p^Y$ . The prices of fragments N and M are  $p^N$  and  $p^M$ . If  $a_{ij}$  represents the quantity of factor i required per unit output of goods j, the basic competitive equilibrium without offshoring is determined by factor market clearing conditions and zero profit conditions.

Factor market clearing conditions in country H:

$$a_{TX}Q^X = \bar{T} \quad (2)$$

$$a_{SM}Q^M = \bar{S} \quad (3)$$

$$a_{LX}Q^X + a_{LN}Q^N = \bar{L} \quad (4)$$

$$a_{KN}Q^N + a_{KM}Q^M = \bar{K} \quad (5)$$

Zero profit conditions of firms in Country H:

$$a_{TX}r_T + a_{LX}r_L = 1 \quad (6)$$

$$a_{LN}r_L + a_{KN}r_K = p^N \quad (7)$$

$$a_{KM}r_K + a_{SM}r_S = p^M \quad (8)$$

Perfect Competition of industry Y ensures that

$$a_{NY}p^N + a_{MY}p^M = p^Y \quad (9)$$

The exogenous variables are product prices ( $p^j$ ), factor endowments ( $\bar{T}, \bar{L}, \bar{K}, \bar{S}$ ) and techniques of production ( $f^j$ ). So equation (2) to equation (8) could be taken to represent all the equilibrium relationships for a competitive economy. Competition ensures that unit costs are minimized, and each  $a_{ij}$  depends upon the ratio of factor prices in sector j. Solve equation (2) (3) for each  $Q^j$  and substitute into equation (4) (5) to obtain equation (10):

$$\bar{L} - \frac{a_{LX}}{a_{TX}}\bar{T} = \frac{a_{LN}}{a_{KN}}(\bar{K} - \frac{a_{KM}}{a_{SM}}\bar{S}) \quad (10)$$

Since the  $a_{ij}$  depend on factor prices, equation (6) (7) (8) (10) provide a set of four relationships in the four factor prices and exogenous parameters of commodity prices and factor endowments. Consequently, the factor prices could be found at the equilibrium before offshoring. So are the outputs.

The direct effect of offshoring is to reduce the unit cost of offshoring component. The story is best reveal by considering the way in which the equilibrium is disturbed by arbitrary changes in offshoring component cost (also changes in factor endowment if offshoring takes place with international capital mobility). We will discuss the changes of equilibrium after offshoring in the next two sections. Lets start with the case that international capital mobility is allowed.

## 2.2 Offshoring with international capital mobility

Now lets consider what will happen if the unskilled labour wage is lower in country F and offshoring is applicable. The lower cost of production in country F gives firms in H an incentive

to relocate the production to a lower cost place by offshoring. But the specific factor is not only specific to industry, but also specific to country, which means land and skilled labour in home cannot be replaced by those in foreign. Therefore, only intermediate product N can be outsourced.

We further assume that firms prefer establishing an affiliate with FDI rather than arm-length transaction because of better ownership and management system. In order to make the analysis simple and delete the effect of capital movement for higher rent, we assume that capital price in domestic and foreign equals before offshoring<sup>2</sup> ( $r_K = r_K^*$ ). If unskilled labour wage in foreign is less than that in home ( $r_L > r_L^*$ ), and the technology for production N in home and foreign are the same ( $a_{ij} = a_{ij}^*$ ), then offshoring of N from home to foreign will happen only if

$$a_{LN}r_L > a_{LN}r_L^* + c \quad (11)$$

$c$  is the transport cost of unit product N. If country F is a big economy with perfectly elastic unskilled labour supply, the production cost of N is constant. The direct effect of offshoring fragment N from country H to country F is to lower the production cost of N, and the pre-offshoring equilibrium is disturbed by a reduction in  $p^N$ . Differentiating equation (6) to (10) you will get equations below:

$$\theta_{TX}\hat{r}_T + \theta_{LX}\hat{r}_L = 0 \quad (12)$$

$$\theta_{LN}\hat{r}_L + \theta_{KN}\hat{r}_K = \hat{p}^N \quad (13)$$

$$\theta_{SM}\hat{r}_S + \theta_{KM}\hat{r}_K = \hat{p}^M \quad (14)$$

$$\theta_{NY}\hat{p}^N + \theta_{MY}\hat{p}^M = 0 \quad (15)$$

$$\frac{\hat{L} + \lambda_{LX}(\sigma_X(\hat{r}_L - \hat{r}_T) - \hat{T})}{\lambda_{LN}} = \frac{\hat{K} + \lambda_{KM}(\sigma_M(\hat{r}_K - \hat{r}_S) - \hat{S})}{\lambda_{KN}} + \sigma_N(\hat{r}_K - \hat{r}_L) \quad (16)$$

The " $\wedge$ " over a variable denotes the relative change in that variable (e.g.  $\hat{r}_T$  is  $dr_T/r_T$ ). The  $\theta_{ij}$  refers to the cost share of factor  $i$  in industry  $j$  which is constant for Cobb-Douglas production function (e.g.  $\theta_{TX}$  is  $a_{TX}r_T/(a_{TX}r_T + a_{LX}r_L)$ ).  $\lambda_{ij}$  refers to the fraction of mobile factor  $i$  absorbed by the industry  $j$  (e.g.  $\lambda_{LN}$  is  $a_{LX}Q^X/(a_{LX}Q^X + a_{LN}Q^N)$ ).  $\sigma_j$  refers to the elasticity of substitution between factors in industry  $j$  (e.g.  $\sigma_X$  is  $(\hat{a}_{TX} - \hat{a}_{LX})/(\hat{r}_L - \hat{r}_T)$ ).

If offshoring takes place in form of FDI, from the assumption above we know that  $\hat{T} = \hat{L} = \hat{S} = 0, \hat{r}_K = 0$ . So factor price effect of changes in intermediate Ns price and capital outflow are provided below.

$$\hat{r}_L = \frac{\hat{p}^N}{\theta_{LN}} < \hat{p}^N < 0 \quad (17)$$

$$\hat{r}_S = \frac{\hat{p}^M}{\theta_{SM}} > \hat{p}^M = -\frac{\theta_{NY}\hat{p}^N}{\theta_{MY}} > 0 \quad (18)$$

$$\hat{r}_T = -\frac{\theta_{NY}\hat{p}^N}{\theta_{TX}\theta_{LN}} > 0 \quad (19)$$

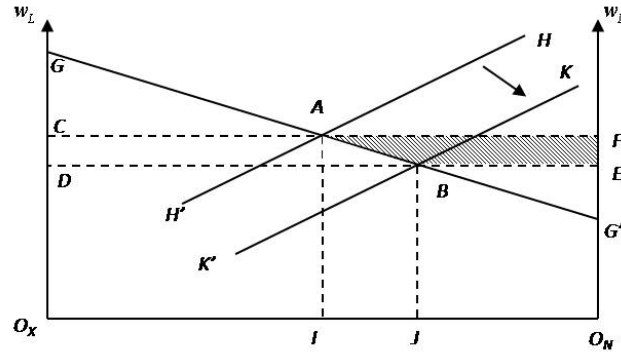
$$\hat{K} = \left( \frac{\lambda_{LX}\lambda_{KN}\sigma_X}{\lambda_{LN}\theta_{TX}\theta_{LN}} + \frac{\sigma_N}{\theta_{LN}} \right) \hat{p}^N + \frac{\lambda_{KM}\sigma_X}{\theta_{SM}} \hat{p}^M \quad (20)$$

It is clear that the return for skilled labour increases more proportional than changes of price of M, and the return for unskilled labour decrease more proportional than changes of price of N.

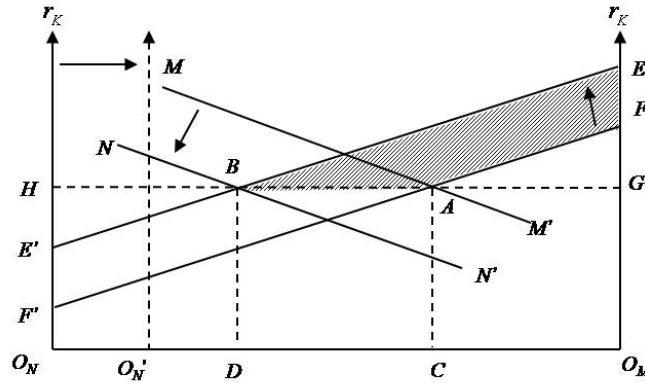
<sup>2</sup>We use superscript \* to present variables in foreign country.

The return for land increase more proportional than changes of price of N if  $\theta_{LX}/\theta_{TX}\theta_{LN} > 1$ . This is because the changes in commodity price must be trapped between the changes in the returns to factors used to produce each commodity.

The intuition of the equilibrium behind the equations is explained with the help of Figure 2. In Figure 2(a)  $GG'$  and  $HH'$  are the demand curves for unskilled labour in sector X and N, respectively. Given the endowment of land in sector X,  $GG'$  is unique and  $HH'$  can move up or down for different capital used in sector N and different price of N. In Figure 2(b)  $MM'$  and  $FF'$  are the demand curves for capital in sector N and M, respectively. Given the endowment of skilled labour and price of M,  $FF'$  is unique and  $MM'$  can move up or down for different unskilled labour used in sector N.



(a) Unskilled labour in sector X and N



(b) Capital in sector N and M

Figure 2: Factor movement after offshoring

If equation (11) is satisfied, then offshoring of intermediate N will happen and capital in sector N begins to move to foreign in the form of FDI to produce N. Now firms can produce the intermediate with a lower price, which will certainly decrease the price of N, and the  $HH'$  in Figure 2(a) moves downward to  $KK'$ . Unskilled labour formerly used to produce N moves to nowhere but sector X and capital formerly used to produce N moves abroad or to the sector M. Unskilled labour wage decreases and price of land increase because of the marginal revenue of land increases as more unskilled labour is used in sector X. As more intermediate N and less intermediate M are used to produce Y, it will increase the price of M. The skilled-labours wage will increase as the price of the other factor capital is constant. This process is shown in Figure

2(b), where FDI outflow decreases the capital endowment at home, accompanied by a right shift from  $O_N$  to  $O'_N$ , and the demand curve of capital in sector N  $MM'$  moves down to  $NN'$  because of the falling price of N, and the demand curve of capital in sector M  $FF'$  move up to  $EE'$  because of the rising price of M. This process will continue until the cost of producing intermediate N at home and abroad equals. At the new equilibrium, point B in figure 2(a) and 2(b), more X and more intermediate M are produced as more factors are allocated in industry X and sector M, and the total quantity of intermediate N from home and abroad are increased as  $Q^N/Q^M$  is larger if  $p^N/p^M$  is smaller.

How much capital is moved abroad could be illustrated by Figure 3. The upper right quadrant demonstrates unskilled labour demand in sector X, and  $OE$  is the endowment of unskilled labour. The lower left quadrant demonstrates capital demand in sector M and  $OH$  is the endowment of capital. Point A and B are the equilibrium before and after offshoring. The upper left quadrant shows the equilibrium set of  $r_L$  and  $r_K$ . If equation (11) is satisfied, the direct effect of offshoring is to decrease the production cost of N at home to the level of production cost at foreign with the transport cost included. The isoquant of N illustrated in the lower right quadrant.  $NO$  is the isoquant of intermediate N at the after-offshoring equilibrium price. Given Cobb-Douglas production function of N,  $ON$  is the capital-unskilled labour ratio at the factor price before offshoring. As the relative price of unskilled labour over capital decreases, the capital-unskilled labour ratio moves towards unskilled labour, shown as  $ON$ . Given domestic equilibrium factor price after offshoring ( $r_K$  and  $(r_L^* + c)/a_{LN}^*$ ) and the amount of unskilled labour used in sector N (shown as  $DE$ ), we know that the amount of capital used in sector N in country H is  $IJ$ , and investment to foreign country is  $KH - IJ$ .

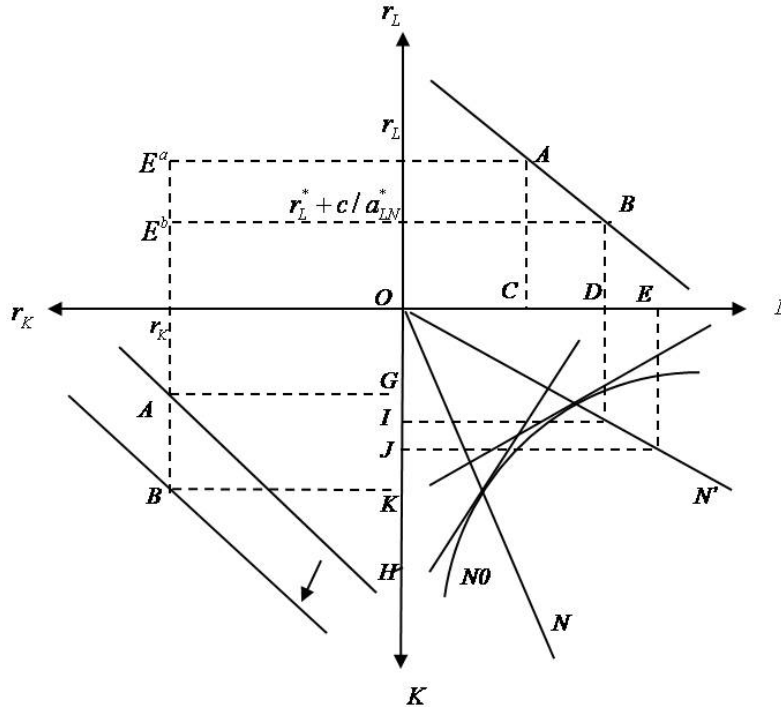


Figure 3: Equilibrium after offshoring

However, it is not necessary to have such equilibrium of incomplete specialization. If the demand curve for unskilled labour in sector X is very flat, it could be that when all of the unskilled labour is used to produce X, domestic production cost of intermediate N is still higher than



that at foreign. Consequentially, all the intermediate N are outsourced to foreign and firms in H specialize in intermediate product M. At the equilibrium, consistent with equilibrium above, the price of land increases as more unskilled labour is allocated in industry X, and the skilled wage increase as the price of intermediate M increases, and the unskilled wage decreases, but higher than foreign effective unskilled wage, which is  $r_L^* + c/a_{LN}^*$ .

**Proposition One:** In the specific factor model with land and skilled labour as specific factor, offshoring with international factor mobility will drive the price of unskilled labour down, increase the price of specific factor, and enlarge the relative wage of skilled-unskilled workers. This conclusion is irrelevant to factor intensity of offshoring fragment and specialization degree at equilibrium after offshoring.

**Proof:** See equations(17), (18), (19).

### 2.3 Offshoring without international capital mobility

Now lets consider another situation of offshoring if capital cannot move internationally. We keep other assumptions from above that unskilled wage at country H is larger than that in country F and capital price equals before offshoring. Country F is a large economy with perfect elasticity of supply of capital and unskilled labour, which means the production cost of intermediate N is constant in country F. The necessary condition that offshoring happens is still equation(11), which is production cost at home is larger than that in foreign plus transports cost.

If firms in country H begin to buy intermediate N from foreign country and it breaks the existing equilibrium. Much similar to the case above, the direct effect of offshoring is to reduce the production cost of intermediate N at country H to the level of F, which will decrease the price of N and increase the price of intermediate M in order to keep the price of Y unchanged. But now capital cannot move internationally. Knowing  $\hat{T} = \hat{L} = \hat{S} = \hat{K} = 0$ , we will get the changes of factor prices by solving equation (12) to (15) all together.

$$\hat{r}_L = \Delta \hat{p}^N < 0 \quad (21)$$

$$\hat{r}_T = -\Delta \frac{\theta_{LX}}{\theta_{TX}} \hat{p}^N > 0 \quad (22)$$

$$\hat{r}_S = \Phi \hat{p}^M = -\Phi \frac{\theta_{NY} \hat{p}^N}{\theta_{MY}} > 0 \quad (23)$$

$$\hat{r}_K = \frac{\hat{p}^M - \theta_{SM} \hat{r}_S}{\theta_{KM}} \quad (24)$$

Where

$$\Delta = \frac{\left( \frac{1}{\theta_{KN}} + \frac{\theta_{NY}}{\theta_{MY} \theta_{SM}} \right) \frac{\lambda_{KM} \sigma_M}{\lambda_{KN}} + \frac{\sigma_N}{\theta_{KN}}}{\frac{\lambda_{LX} \sigma_X}{\lambda_{LN} \theta_{TX}} + \frac{\lambda_{KM} \theta_{LN} \sigma_M}{\lambda_{KN} \theta_{KN} \theta_{SM}} + \frac{\sigma_N}{\theta_{KN}}} > 0$$

$$\Phi = \frac{\left( \frac{\lambda_{LX} \sigma_X}{\lambda_{LN} \theta_{LN} \theta_{TX}} + \frac{\sigma_N}{\theta_{LN}} \right) \frac{\theta_{MY}}{\theta_{NY}} + \left( \frac{\lambda_{KM} \sigma_M}{\lambda_{KN}} + \frac{\lambda_{LX} \theta_{KN} \sigma_X}{\lambda_{LN} \theta_{LN} \theta_{TX}} + \frac{\sigma_N}{\theta_{LN}} \right) \frac{1}{\theta_{KM}}}{\frac{\lambda_{LX} \theta_{SM} \theta_{KN} \sigma_X}{\lambda_{LN} \theta_{KM} \theta_{LN} \theta_{TX}} + \frac{\theta_{SM} \sigma_N}{\theta_{KM} \theta_{LN}} + \frac{\lambda_{KM} \sigma_M}{\lambda_{KN} \theta_{KM}}} > 0$$

It is clear that the returns for land and skilled-labour will increase and return for unskilled-labour will decrease. There will be a magnification effect of unskilled (or skilled) labour if  $\Delta > 1$  (or  $\Phi > 1$ ). The price of capital may go up (or down) depends on  $\theta_{SM} \Phi < (or >) 1$ .

The intuition of the equilibrium behind is similar to the section above. After offshoring, unskilled labour which is used to produce N moves to industry X and increases the price of land at the expense of decreasing unskilled wage. Capital which is used to produce N moves nowhere but sector M and skilled wage increase by the joint force of rising price M and more inflowing capital. Now it is hard to tell the changes of capital price. As shown in figure 2(b), a reduction of price of N will move the demand curve for capital in sector N down and a increase of price of M will move the demand curve for capital in sector M up, but it is not necessary to keep the new intersection point at point B, which depends on the income effect and substitute effect.

As illustrated in figure 4 ,  $M_0$  is the isoquant of intermediate M before offshoring. An increase in the price of M shift the isoquant inward to  $M_1$  and the price of skilled labour and capital will increase at the same proportion if the capital-skilled labour ratio is unchanged, called income effect. However, this is not stable as more capital is attracted to sector M because of higher rent. Skilled labour is replaced by a cheaper capital so the capital-skilled labour ratio is increased and the relative capital-skilled labour return is decreased, called substitution effect. The skilled wage goes up definitely while the capital price is determined by which effect is stronger.

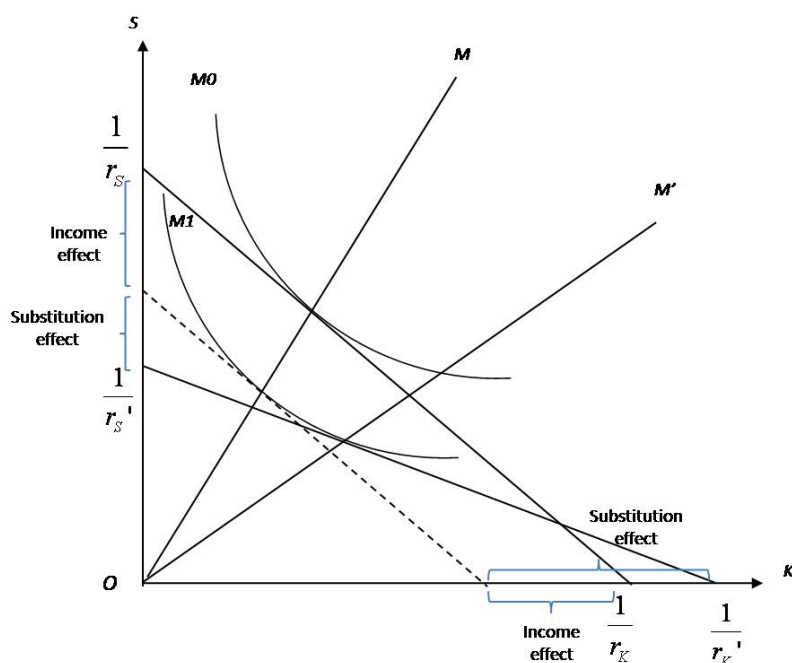


Figure 4: Changes of capital price after offshoring without international capital mobility

Again, it is not necessary to have such an incomplete specialization of equilibrium. If the demand curve for unskilled labour in sector X is very flat as  $GG'$  in figure 2(a), it could be that when all of the unskilled labour is used to produce X domestic production cost of N is still higher than foreign effective cost of N. Consequentially, all the intermediate N are outsourced to foreign and firms in country H specialize in intermediate product M. At the equilibrium, consistent with equilibrium above, the price of land increases as more unskilled labour is allocated in industry X, and the skilled workers' wage increase as both the price of intermediate M and capital used in sector M increase. Unskilled wage decreases and the change of capital price is ambiguous, which depends on income effect and substitution effect.

**Proposition Two:** In the specific factor model with land and skilled labour as the specific factor, offshoring without international factor mobility will increase the price of specific factors, decrease the price of unskilled labour, and enlarge the gap between skilled and unskilled labour. This conclusion is irrelevant to factor intensity of offshoring fragment and specialization degree at equilibrium.

**Proof:** See equation(21) to (24).

Table 1 in Appendix summarizes the changes of factor prices and outputs after offshoring with and without international factor mobility.  $\uparrow\downarrow$   $-?$  denote an increasing, decreasing, unchanged and unsure movement. It is clear that output of each industry and relative wage of skilled and unskilled labor increase in both cases, which is irrelevant to factor intensity, specialization degree at equilibrium and international capital mobility.

### 3 Welfare Effect of Offshoring

Although the conclusion of factor price effect of offshoring in H-O framework has not reached an agreement, the positive effect of offshoring on welfare is accepted widely. Does the welfare of home country gain from offshoring in specific factor model? Let us resort to the familiar calculus of areas if the welfare of a country is defined as the national income of factor owners. From last chapter we know that the income for unskilled labour is shrinking, and the income for land owners and skilled labour is increasing. The income for capital owners is unchanged in the case of offshoring with international capital mobility as it gets the same return in home and abroad, or uncertain in the case of offshoring without international capital mobility. So the overall change of welfare at home is calculated by the changes of all the incomes for each factor.

Take the case of offshoring with international capital mobility by Figure 2(a) and Figure 2(b) as an example<sup>3</sup>. In Figure 2(a), area  $GAC$  measures the income of land owners before offshoring and area  $CO_XO_NF$  measures the income of unskilled labour. Area  $CABD$  measures the additional income obtained by land owners after offshoring, and the income of unskilled labour is lost by the area  $CDEF$  after offshoring. The net loss of incomes for land owners and unskilled labour is shown clearly in the shadow area  $ABFE$  in Figure 2(a). Moreover, in Figure 2(b) the income obtained by skilled labour increases from area  $GAF$  to the area  $GEB$  after offshoring, and income of capital is unchanged as the area  $HGO_MO_N$ . So the net gain of capital owners and skilled labour is measured by shadow area  $BAFE$ . However, It is not clear to tell the overall welfare of home country after offshoring in specific factor model which is area  $BAFE$  minus area  $ABFE$ , but at least we know that the specific factor gains and the industrially mobile factor, unskilled labour, loses. Welfare of home country is more likely to lose after offshoring if the difference of unskilled labour wage between countries is larger, or the price of M increase less for a given reduction of the price of N, which means a smaller  $\theta_{NY}/\theta_{MY}$  from equation (9). Because unskilled labour loses more if the unskilled wage difference between countries are larger and skilled labour gains less from a smaller rise of price of M.

It is worth trying to show the welfare in a mathematical way and relate the changes of welfare to the parameters we have. The changes of welfare are measured by the changes of incomes obtained by factor owners:

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<sup>3</sup>The explanation of welfare after offshoring without international capital mobility is similar to that with international capital mobility, except the returns for capital. Land owners and skilled labour gain, and unskilled labour loses after offshoring. Because the change of capital rental is dependent on income and substitute effect, it is hard to tell whether capital owners gain. This process could be drawn in figures as well.

$$dW = dr_T \times T + dr_L \times L + dr_K \times K + dr_S \times S \quad (25)$$

and equivalently,

$$\hat{W} = \hat{r}_T \theta_{TW} + \hat{r}_L \theta_{LW} + \hat{r}_K \theta_{KW} + \hat{r}_S \theta_{SW} \quad (26)$$

Where  $\theta_{iW}$  is the income share of factor  $i$  in welfare before offshoring. Taking  $dr_K = 0$  and equations (17) to (19) back into equation (26), we get the changes of welfare for the case of offshoring with international capital mobility below:

$$\hat{W} = \left( -\frac{\theta_{LX}\theta_{TW}}{\theta_{TX}\theta_{LN}} - \frac{\theta_{NY}\theta_{SW}}{\theta_{SM}\theta_{MY}} + \frac{\theta_{LW}}{\theta_{LN}} \right) \hat{p}^N \quad (27)$$

And home country welfare will be worsened after offshoring if

$$\frac{\theta_{LW}}{\theta_{LN}} - \frac{\theta_{LX}\theta_{TW}}{\theta_{TX}\theta_{LN}} - \frac{\theta_{NY}\theta_{SW}}{\theta_{SM}\theta_{MY}} > 0 \quad (28)$$

Similarly, taking equations (21) to (24) back into equation (26), we get the changes of welfare for the case of offshoring without international capital mobility below:

$$\hat{W} = \left( \left( \theta_{LW} - \frac{\theta_{LX}\theta_{TW}}{\theta_{TW}} \right) \Delta + \left( 1 + \frac{\theta_{KW}}{\theta_{KM}} \right) \frac{\theta_{SM}\theta_{NY}\Phi}{\theta_{MY}} - \frac{\theta_{NY}\theta_{KW}}{\theta_{KM}\theta_{MY}} \right) \hat{p}^N \quad (29)$$

And home countrys welfare will be worsened after offshoring if

$$\left( \theta_{LW} - \frac{\theta_{LX}\theta_{TW}}{\theta_{TW}} \right) \Delta + \left( 1 + \frac{\theta_{KW}}{\theta_{KM}} \right) \frac{\theta_{SM}\theta_{NY}\Phi}{\theta_{MY}} > \frac{\theta_{NY}\theta_{KW}}{\theta_{KM}\theta_{MY}} \quad (30)$$

**Proposition Three: The welfare of home country might be worsened after offshoring with(or without) international capital mobility, if equality (28) (or (30)) is satisfied.**

**Proof:** See equations (27) (28) (29) (30).

## 4 Unskilled Labour Training

There is a chance to get educated. Suppose some of the unskilled labour can be trained to equivalent skilled labour. The cost is so small that we can ignore it. Whats the effect of labour endowment change on factor returns? The answer is not as simple as above. We take the equilibrium after offshoring with and without international capital mobility but before labour training as the benchmark, and compare the changes of factor prices and outputs after training with it.

After unskilled labour training, we have  $\hat{T} = 0, \hat{L} < 0, \hat{S} > 0, r\hat{K} = 0$  for the case of offshoring with international capital mobility;  $\hat{T} = \hat{K} = 0, \hat{L} < 0, \hat{S} > 0$  for the case of offshoring without international capital mobility. Taking these back into equation (12) to (16), we can solve the new equilibrium.

**Lemma 1 : If offshoring is in the form of FDI, unskilled labour training has no effect on equilibrium factor price. The welfare of home country is better after labour training.**

**Proof:** If the international capital mobility is allowed, taking  $\hat{T} = 0, \hat{L} < 0, \hat{S} > 0, r_K = 0$  back into equation (12) to (16), we can solve the new equilibrium.

$$\hat{r}_L = \frac{\hat{p}^N}{\theta_{LN}}, \hat{r}_S = -\frac{\theta_{NY}\hat{p}^N}{\theta_{MY}}, \hat{r}_T = -\frac{\theta_{NY}\hat{p}^N}{\theta_{TX}\theta_{LN}} \quad (31)$$

the changes of factor prices after labour training are exactly the same to equation (17) to (19), which are the changes of factor prices after offshoring without labour training.

From equation (27), we know

$$\frac{d\hat{W}}{d\theta_{SW}} = -\frac{\theta_{NY}}{\theta_{SM}\theta_{MY}}\hat{p}^N > 0, \frac{d\hat{W}}{d\theta_{LW}} = \frac{\hat{p}^N}{\theta_{LN}} > 0.$$

So  $d\hat{W} > 0$ , when  $d\theta_{SW} > 0$  and  $d\theta_{LW} < 0$ .

The international mobility of capital will make sure that the rent of capital will not change, which will not only keep the wage of skilled labour unchanged as the prices of intermediate N and M are unchanged, but also keep the unskilled labour unchanged because the cost of N at home should equal that at foreign at the equilibrium. Now, the welfare of home country is also improved as national income increase as less unskilled labour and equivalent more skilled labour are in the economy.

**Lemma 2:** If there is no international factor mobility, unskilled labour training for equivalent skilled labour will make the unskilled labour wage decrease more (or less), the skilled labour wage increase less (or more), the return for land increase more (or less), and the return for capital improved (worsened), only when the skilled-labour capital ratio in sector M is less (or greater) than unskilled-labour capital ratio in sector N.

**Proof:** If international mobility of capital is not allowed, the equilibrium of labour training is solved by taking  $\hat{T} = \hat{K} = 0, \hat{L} < 0, \hat{S} > 0$  back into equation (12) to (16):

$$\begin{aligned} \hat{r}'_L &= \Delta\hat{p}^N - \frac{1}{\Theta} \left( \frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}\hat{S}}{\lambda_{KN}} \right) < 0, \hat{r}'_T = -\frac{\theta_{LX}}{\theta_{TX}}\hat{r}'_L > 0, \\ \hat{r}'_S &= \Phi\hat{p}^M - \frac{1}{\Omega} \left( \frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}\hat{S}}{\lambda_{KN}} \right) > 0, \hat{r}'_K = \frac{\hat{p}^M - \theta_{SM}\hat{r}_S}{\theta_{KM}} \end{aligned}$$

where

$$\begin{aligned} \Theta &= \frac{\lambda_{LX}\sigma_X}{\lambda_{LN}\theta_{TX}} + \frac{\lambda_{KM}\theta_{LN}\sigma_M}{\lambda_{KN}\theta_{KN}\theta_{SM}} + \frac{\sigma_N}{\theta_{KN}} > 0, \\ \Omega &= \frac{\lambda_{LX}\theta_{SM}\theta_{KN}\sigma_X}{\lambda_{LN}\theta_{KM}\theta_{LN}\theta_{TX}} + \frac{\theta_{SM}\sigma_N}{\theta_{KM}\theta_{LN}} + \frac{\lambda_{KM}\sigma_M}{\lambda_{KN}\theta_{KM}} > 0. \end{aligned}$$

From equation (21) to (24), we know

$$\hat{r}'_L - \hat{r}_L = -\frac{1}{\Theta} \left( \frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}\hat{S}}{\lambda_{KN}} \right), \hat{r}'_T - \hat{r}_T = \frac{\theta_{LX}}{\theta_{TX}} \frac{1}{\Theta} \left( \frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}\hat{S}}{\lambda_{KN}} \right), \quad (32)$$

$$\hat{r}'_S - \hat{r}_S = -\frac{1}{\Omega} \left( \frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}\hat{S}}{\lambda_{KN}} \right), \hat{r}'_K - \hat{r}_K = \frac{\theta_{SM}}{\theta_{KM}} \frac{1}{\Omega} \left( \frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}\hat{S}}{\lambda_{KN}} \right) \quad (33)$$

If the unskilled labour becomes equivalent skilled labour after training ( $dL = -dS < 0$ ), we have

$$\frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}\hat{S}}{\lambda_{KN}} = \left( \frac{1}{\lambda_{LN}L} - \frac{\lambda_{KM}}{\lambda_{KN}S} \right) dL.$$

If the skilled-labour capital ratio in sector M is less (or larger) than unskilled-labour capital ratio in sector N, we have

$$\frac{S}{K\lambda_{KM}} < (>) \frac{L\lambda_{LN}}{K\lambda_{KN}},$$

which means

$$\frac{\hat{L}}{\lambda_{LN}} + \frac{\lambda_{KM}\hat{S}}{\lambda_{KN}} > (<) 0.$$

From equation(32) (33), we know

$$\hat{r}'_L < (>) \hat{r}'_L, \hat{r}'_S < (>) \hat{r}'_S, \hat{r}'_T < (>) \hat{r}'_T, \hat{r}'_K < (>) \hat{r}'_K.$$

It is easy to understand the intuition behind those equations. Lets begin with the simplest.

If  $\frac{S}{KM} = \frac{L}{KM}$ , it means the capital which was used to produce N with unskilled labour is just enough for producing M with the same amount of newly trained skilled labour, given the equilibrium factor price. So factor price will not change at all. The output of N decreases domestically and increases abroad, and the output of M increases as more factors are allocated in sector M.

If  $\frac{S}{KM} < \frac{L}{KM}$ , it means the capital which was used to produce N with unskilled labour is not enough for producing M with the same amount of newly trained skilled labour, given the equilibrium factor price. There is a shortage for capital, so the price of skilled labour will decrease and the price of capital will increase. But this is not a stable equilibrium because it breaks the condition that production cost of N in H and F equals. So price adjustment continues. At this moment, the cost of N in H is higher than that in F, resulting in that more N is outsourced. Further offshoring drives more capital go to sector M, which help to satisfy the exceeding demand for capital in sector M, and more unskilled labour go to sector N, which drops the price of unskilled labour. This process will continue until that the costs of production N in H and F equal again. In the end, unskilled labour wage goes down as more unskilled labour is used in industry X, and price of capital goes up because the production cost in H equals that in F which is unchanged. The price of land goes up and skilled wage goes down as more skilled labour is supplied after training. Its not easy to say whether the relative wage gap goes up or down, as both unskilled and skilled labours are paid less. But we know that offshoring is reinforced.

If  $\frac{S}{KM} > \frac{L}{KM}$ , it means capital is redundant compared to trained skilled labour, and the price of skilled labour will increase and the price of capital will decrease. Now the production cost of N in H is lower than that in F. Offshoring will be reduced and labour used in sector X go back to sector N, which lead a rise in unskilled labour price, and capital used in sector M go back to N, which prevent capital price from declining. This process continues until that the costs of production N in H and F equal again. Again, its hard to say the relative wage gap as skilled and unskilled wage goes up at the same time. But we know that offshoring is weakened.

However, we shouldnt forget the situation of Complete Specialization. If the pre-training equilibrium without international capital mobility is that all the unskilled labour is employed in sector X, the reduction in supply of unskilled labour will leads to a rise in unskilled labour wage and a decline in factor price of land. Similarly, the increase in supply of skilled labour will lead

to a decline in skilled labour wage and a rise in factor price of capital. So the relative wage gap has been narrowed. The domestic price for factors used in the production of N increase, which in turn reinforces the necessary condition for Complete Specialization of Offshoring. If the pre-training equilibrium offshoring is with international capital mobility, analysis will be much easier. Unskilled labour training will increase the wage of unskilled labour and decrease the rent for land, just as illustrated in the case of offshoring without international capital mobility. International Capital mobility will keep the capital price unchanged, which guarantees that the skilled labour wage is unchanged as well. As illustrated in Lemma 1, the overall welfare of home country will be improved as the gains for the unskilled labour can compensate the net loss in land owners.

Table 2 in Appendix summarizes the changes of factor prices after labour training. Compared to the pre-training equilibrium after offshoring with international capital mobility, the welfare of home country will be improved. If the pre-training equilibrium of offshoring without international capital mobility is complete specialization, offshoring will be reinforced after labour training and the relative wage will decline. If the pre-training equilibrium of offshoring without international capital mobility is incomplete specialization, the relative wage gap depends on relative capital/labour ratio in sector N and M.

**Proposition Four: If arbitrary amount of unskilled labour is trained for equivalent amount of skilled labour, changes of factor prices are dependent on pre-training equilibrium, international capital mobility and capital intensity of fragments. Relative wage of skilled and unskilled workers will be narrowed for sure only when the pre-training equilibrium is complete specialization.**

**Proof:** See Lemma 1, Lemma 2 and Table 2.

## 5 Concluding Remarks

Concerns about skilled and unskilled wage gap-enlarging implication and welfare-reducing implication of offshoring appear to be reasonable. By allowing skilled labour to be specific to the industry, offshoring from a small open economy will improve the gains of specific factors (land and skilled labour), and harm the industrially mobile nonspecific factor (unskilled labour). Consequentially, the relative wage between skilled and unskilled labour is increasing, and the output of each industry is expanding. These conclusions are robust and irrelevant to capital mobility between countries, complete specialization or incomplete specialization at equilibrium and factor intensity of offshoring fragment. The price of capital, which moves between sectors within an industry rather than industries, is unchanged if international capital mobility is allowed, or dependent on the price effect of rising price of M and substitution effect between capital and skilled labour in the case of offshoring with an arm-length transaction. See 1 in Appendix A for details. The welfare effect of offshoring in the specific factor model is not necessarily positive, if welfare is defined as the national incomes of factor owners. The overall welfare gains is measured by area  $BAFE$  in figure 2(b) minus area  $ABFE$  in figure 2(a), and welfare could be worsened after offshoring more likely if the difference of unskilled wage between home is larger or price of M increases less given a reduction in price of N.

The aim of this work is to show whether the factor price effect of offshoring in specific factor model is robust. Not surprisingly, The conclusion here is more robust than that in H-O framework which depends on factor intensity of offshoring fragment, and also more robust than Kohler [2001] whose conclusion is also from a specific framework that wage will decrease if offshoring takes place with FDI or labour-intensive fragment is outsourced without FDI. In con-

trast to Kohler [2001], equilibrium of offshoring could be complete specialization or incomplete specialization both with and without international capital mobility, dependent on the unskilled wage gap between countries and the slope of unskilled labour demand curve in industry X.

The mechanism behind the model is consistent with Grossman and Rossi-Hansberg [2008]. They illustrate 3 different effect of offshoring, which is relative-price effect, productivity effect and input-supply effect. In our paper, firstly we assume that country H is a small economy facing given world price, but there is actually relative price effect in our paper. Lowering the cost of offshoring fragment N increases the price of another fragment M, as the final goods price of Y is given by the world market. The rise in the price of fragment M benefits its specific factor, while the decline in the price of fragment N harms the unskilled labour. Secondly, firms in H outsource fragment N to a lower cost location and improve their efficiency. Factor price changes after offshoring, acting like a sector-biased technology change. Finally, after offshoring, unskilled labour and capital which are formerly used for producing N need to be absorbed by other sectors to clear the factor market. Factor price changes because of the changes of factor used in each sector, which is called input supply effect.

This paper also investigates the effect of factor endowment changes on factor prices. If certain amount of unskilled labour becomes equivalent skilled labour after training and education, the situation of unskilled labour may not be better which depends on pre-training equilibrium, international capital mobility and capital intensity of fragments. If the pre-training equilibrium is complete specialization of offshoring, then we know the skilled-unskilled wage gap will be narrowed, as well expected. If the pre-training equilibrium is incomplete specialization, the skilled-unskilled wage gap depends on the relative capital/labour ratio in each intermediate product in the case of offshoring without FDI, or is constant in the case of offshoring with FDI.

Even if the final goods price is affected after offshoring, lets say a reduction in  $p^Y$ , the conclusions above can be held as well under certain conditions, because the changes of factor prices are according to the changes of price of N and M. So as long as the price of N decreases and the price of M increases after offshoring, the skilled labour and land owner will always gain while the unskilled labour lose, and the welfare of home country may be worsened. However, things will be different if the price of intermediate N and M decreases both. More works will be focused on this extension later.

## Appendix

Table 1: Changes of factor prices and outputs after offshoring

Factor price or output	$r_T$	$r_L$	$r_K$	$r_S$	$r_S/r_L$	$Q^X$	$Q^M$	$Q^Y$
Offshoring With International Factor mobility	↑	↓	—	↑	↑	↑	↑	↑
Offshoring Without International Factor mobility	↑	↓	?	↑	↑	↑	↑	↑

↑↓ —?denote an increasing, decreasing, unchanged and unsure movement.



Table 2: Factor price changes after labour training

Pre-training equilibrium	$r_T$	$r_L$	$r_K$	$r_S$	$r_S/r_L$
<b>Offshoring Without International Factor mobility</b>					
Complete Specialization	↓	↑	↑	↓	↓
Incomplete Specialization					
$\frac{S}{K^M} < \frac{L}{K^M}$	↑	↓	↑	↓	?
$\frac{S}{K^M} = \frac{L}{K^M}$	—	—	—	—	—
$\frac{S}{K^M} > \frac{L}{K^M}$	↓	↑	↓	↑	?
<b>Offshoring With International Factor mobility</b>					
Complete Specialization	↓	↑	—	—	↓
Incomplete Specialization	—	—	—	—	—

↑↓ —?denote an increasing, decreasing, unchanged and unsure movement.

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